A NEW ARBORESCENT SPECIES OF *ZAMIA* (CYCADALES, ZAMIACEAE) FROM THE DEPARTMENT OF HUILA, EASTERN CORDILLERA OF COLOMBIA

Una especie nueva arborescente de *Zamia* (Cycadales, Zamiaceae) del departamento del Huila, Cordillera Oriental de Colombia

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ABSTRACT
Zamia huilensis Calonje, Esquivel, & D.W. Stev., a new arborescent species from the Eastern Cordillera of Colombia (Department of Huila), is described and illustrated. It is compared to *Z. muricata* Willd., which has similar leaflet shape, and to *Z. tolimensis* Calonje, Esquivel & D.W. Stev., with which it shares some reproductive characters. It differs from *Z. muricata* in having an arborescent trunk, beige-yellow to beige ovulate strobili supported by short peduncles, and microsporangia aggregated into a single group on abaxial side of microsporophyll; it differs from *Z. muricata* in the subterranean trunk, dark brown to black ovulate strobili supported by long peduncles, and microsporangia separated into two groups on abaxial side of microsporophylls. It differs from *Z. tolimensis* in having an overall smaller size, leaflets that are not strongly falcate and with margins toothed below the distal half, compared to *Z. tolimensis* which is a much larger plant, and has strongly falcate leaflets that are not toothed below the distal half.

Key words. Cycadales, Zamiaceae, Flora of Colombia, Huila, Zamiaceae.

RESUMEN
Se describe e ilustra *Zamia huilensis* Calonje, Esquivel, & D.W. Stev., una nueva especie arborescente de la Cordillera Oriental de Huila, Colombia. La nueva especie es comparada con *Z. muricata* Willd., con la cual comparte la forma similar

de sus folíolos, y con *Z. tolimensis* Calonje, Esquivel & D.W. Stev., con la cual comparte algunos caracteres reproductivos. Difiere de *Z. muricata* al tener un tronco arborescente, estróbilos ovulíferos amarillo-beige a beige con pedúnculos cortos, y microsporangios agregados en un grupo en la superficie abaxial del microesporofilo, en contraste con *Z. muricata*, que tiene tallo subterráneo, estróbilos ovulíferos de color café oscuro a negro con pedúnculos largos, y microspornagios separados en dos grupos en el lado abaxial de los microesporofilos. Difiere de *Z. tolimensis* al ser una planta generalmente de tamaño más pequeño, y tener folíolos que no son fuertemente falcados y con márgenes con dientes por debajo de la mitad distal, comparado con *Z. tolimensis*, que es una planta mucho más grande y tiene folíolos fuertemente falcados que no tienen dientes por debajo de la mitad distal.

Palabras clave. Zamiaceae, cycadales, Huila, Flora de Colombia, Cordillera Oriental.

INTRODUCTION

Only three collections of *Zamia* L. were reported from the department of Huila in Colombia prior to this publication. The first collection was in 1896 by German naturalist Friedrich Carl Lehmann, near Altamira (then part of the department of Tolima). The next two collections were near Algeciras by American botanists, Francis Raymond Fosberg in 1942, and Elbert L. Little Jr. in 1945, while on a mission to identify native stands of *Cinchona* L. species for use in extracting the anti-malarial drug Quinine. These latter two collections were placed in *Z. poeppigiana* Mart. & Eichler by Stevenson (2001, 2004).

In January of 2012, five new populations of this long-lost taxon were located within the municipalities of Algeciras, Garzón, and Hobo (Huila). These populations were studied extensively during fieldwork coordinated by the Universidad Surcolombiana (Neiva, Huila) in collaboration with the Universidad del Tolima (Ibagué, Tolima, Colombia), the Jardín Botánico José Celestino Mutis (Bogotá, D.C., Colombia), and Montgomery Botanical Center (Miami, FL, USA). New information accumulated from these field studies has led the authors to the conclusion that these plants represent a previously undescribed species, formally described below.

***Zamia huilensis* Calonje, H.E. Esquivel, & D.W. Stev. sp. nov.** Figs.1, 2

TYPE: COLOMBIA. **Huila**: Garzón, 1100-1200 m alt., 16 jan 2012, *H.E. Esquivel et al. 3791* (holotype: TOLI [3 sheets]; isotypes: COL, CUVC, FAUC, HUA, HUAZ, HUQ, JAUM, SURCO, TOLI).

Diagnosis. Species similis ad *Zamia tolimensis* sed cum foliolum marginibus dentatus infra distalis dimidium

Description. Stem epigeous, globose to cylindrical, to 110 cm tall and 7-12 cm wide, erect, typically solitary but occasionally branched. **Cataphylls** chartaceous, narrowly triangular, light beige-yellow to beige tomentose, to 10 cm long, and 3 cm wide at base. **Leaves** pinnately compound, up to 17 per stem apex, straight to slightly arching, to 160 cm long. **Petiole** to 53 cm long, sparsely to moderately armed with prickles to 2.2 mm long, base swollen and glabrous, 2-5 cm wide. **Rachis** to 116 cm long, unarmed or sparsely armed with prickles in the proximal third. **Leaflets** subopposite to subalternate, to 21 pairs per leaf, coriaceous, linear-lanceolate with strongly acuminate tip, straight to slightly falcate, margins dentate with 20-60 teeth on distal 2/3 to ½, light green and glabrous when emerging, glossy bright green at maturity;

basal leaflets 17-36 x 3-6.5 cm; middle leaflets 16-29.7 x 3.8-5.2 cm, spaced 3-6.5 cm apart on rachis; apical leaflets 15-25 x 3.5-5.5 cm. **Eophylls** carrying 2-4 leaflets 6-6.5 x 2-2.3 cm with distinctly toothed margins, petiole 6-10 cm long, rachis 0.3-0.5 cm long.

Pollen strobili two to six per stem apex, to 14 x 3 cm, yellow-beige tomentose, peduncles to 6.5-8.0 x 1-1.4 cm, yellow-beige tomentose with green undertones; microsporophylls arranged in 14-16 orthostichies of 16-25 fertile sporophylls each, obtrullate, 10-11 x 8-9 mm at pollen shedding, bullae encompassing 1/4 to 1/3 of total length of sporophyll, beige-yellow tomentose, face hexagonal, 5-5.2 x 4.2-4.5 mm, distal facet shallowly indented, microsporangia 37-43, 1.2 x 1 mm, limited to the abaxial surface and aggregated into a single group, lower half of pedicels without microsporangia.

Ovulate strobili one or two per apex, erect, cylindrical, beige-yellow tomentose when juvenile, at maturity turning beige-tomentose to glabrous green, 10-30 x 7-11.4 cm, sterile apex obtuse or pungent, 1-2 cm long, strobilus axis glabrous; peduncles 2-5 x 1.5-3 cm, beige-yellow to grey-brown tomentose; megasporophylls arranged in 5-8 orthostichies of 3-9 sporophylls each, megasporophyll pedicels 2.5-3.5 cm long, glabrous, bullae with hexagonal to oblong-hexagonal distal face 2.4-3 x 5-5.2 cm and 1-1.4 cm thick, terminal facet broad, slightly protruding, and indented. *Seeds* with sarcotesta ovoid-pyramidal, bright orange at maturity, 2.5-3.2 x 2.1-2.4 cm. Sclerotesta ovoid to ovoid-pyramidal, 2-2.3 x 1.4-1.8 cm.

Common name. The species is known as "palma de monte" (mountain palm) in the Municipality of Hobo.

Etymology. The specific epithet was chosen to honor Huila, the department in Colombia where this species has been collected.

Habitat and distribution. *Zamia huilensis* occurs in premontane moist forest (sensu Holdridge, 1967) on the foothills of the western slope of the Eastern Cordillera in Huila, Colombia (see Table 1 for associated vegetation). It occurs at elevations ranging from 1000 to 1750 m above sea level in the forest understory on moderate to steep slopes (25º-60º) with a substrate of dark, slightly sandy soils over granitic bedrock covered by a layer of humus.

The annual precipitation within the extent of occurrence for this species ranges from 1300 mm to 1700 mm per year with a bimodal distribution pattern. The rainiest months are April and October through November, and the driest months are August through September and December through January. The temperature ranges from 13° to 30° C, with the annual mean temperature ranging from 18° to 23° C. (Data derived from GIS analysis using Worldclim 1.4 climate layers as described by Hijmans et al., 2005).

Phenology. In January of 2012, both pollen and ovulate strobili were observed at all stages of maturity, from newly emerging to pollen/seed dehiscence.

Ecology. In the five populations studied, plants were locally abundant. Seed set within strobili appeared to be near 100%, and seedlings were common, indicating there are healthy pollinator populations and recruitment is occurring. In the Municipality of Hobo, an elongated pollen strobilus at pollen release stage was observed harboring clavicorn beetles of the genus *Pharaxonotha* Reitt., known pollinators of other *Zamia* species (Tang, 1987; Vovides, 1991; Stevenson et al., 1998). Larvae of a species of *Eumaeus* Hübner, were observed feeding on newly-emergent *Zamia* leaves, and eggs, pupae, and butterflies of this species were also observed (Fig. 2C).

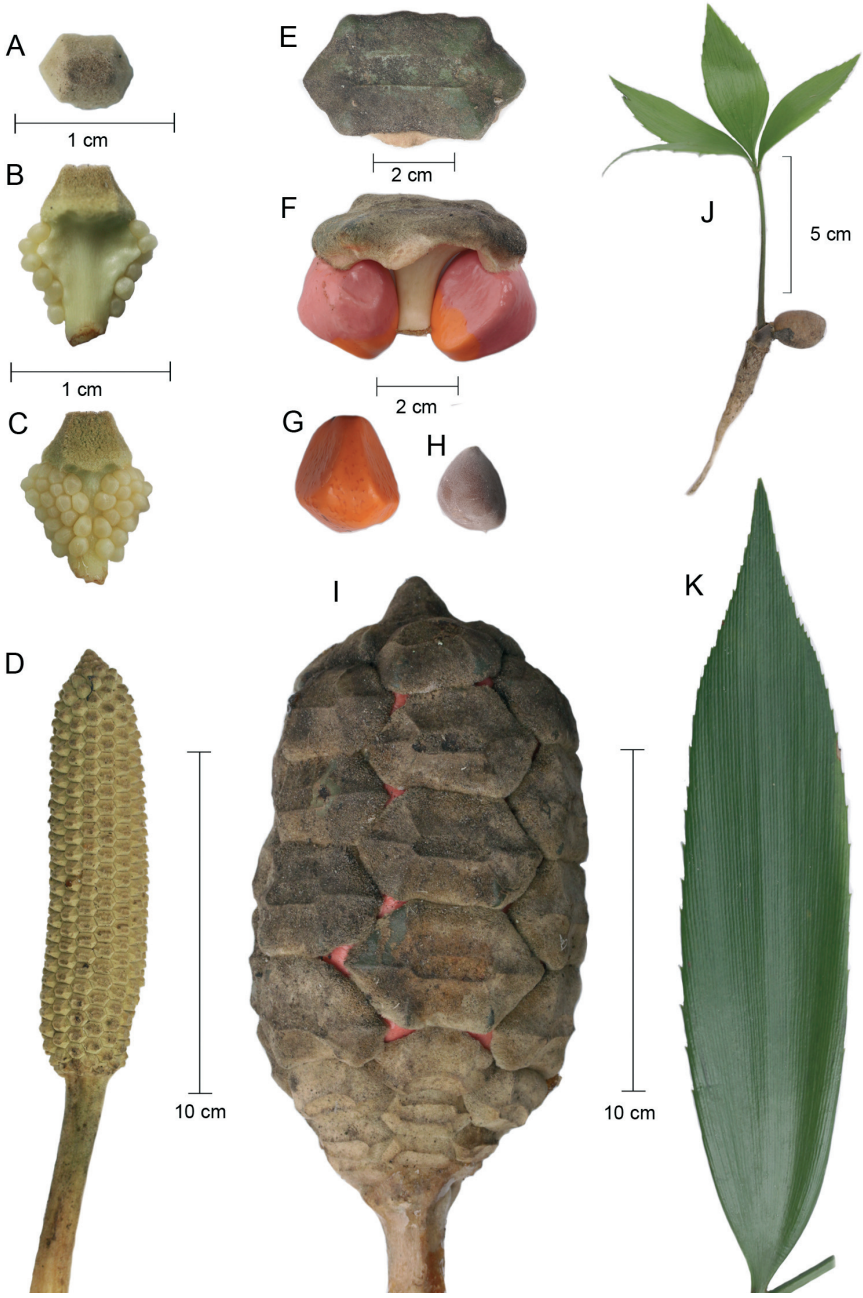

Figure 1. Reproductive and vegetative characters of *Zamia huilensis*. A. Microsporophyll face. B. Microsporophyll, adaxial view. C. Microsporophyll, abaxial view. D. Pollen strobilus near pollen-release stage. E. Megasporophyll face from mature strobilus. F. Mature megasporophyll, adaxial view. Note sarcotesta ripening from distal to proximal end. G. Mature seed sarcotesta. H. Mature seed sclerotesta. I. Near-mature ovulate strobilus. J. Seedling with eophyll. K. Middle leaflet. All photographs derived from type locality plants.

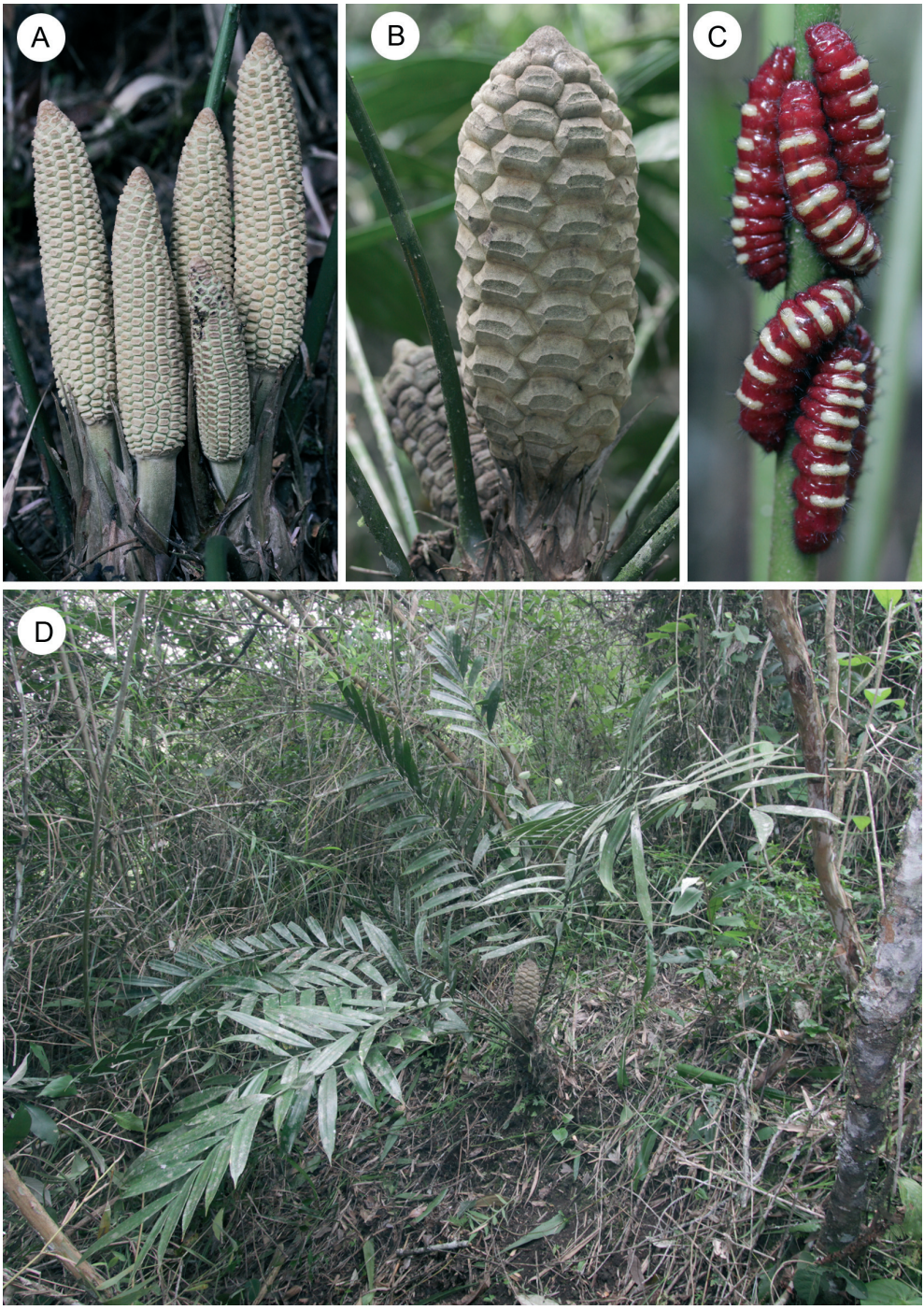

Figure 2. Reproductive and vegetative characters of *Zamia huilensis*, and associated lepidoptera. A. Juvenile pollen strobili. B. Immature ovulate strobilus. C. Larvae of *Eumaeus* sp. D. Ovulate plant in habitat. (A from the type locality; B-D from *Esquivel et al.* 3790).

Table 1. Vegetation associated with *Zamia huilensis* in Algeciras and Garzón municipalities.

Taxon	Family	Algeciras	Garzón
Anthurium nymphaefolium K. Koch & C.D. Bouché	Araceae	X	X
Anthurium cf. *glaucospadix* Croat	Araceae	X	
Baccharis trinervis Pers.	Asteraceae	X	
Calliandra sp.	Fabaceae	X	
Carludovica palmata Ruiz & Pav.	Cyclanthaceae	X	
Cecropia angustifolia Trécul	Urticaceae	X	
Cissampelos pareira L.	Menispermaceae	X	
Clusia grandiflora Splitg.	Clusiaceae	X	
Cordia alliodora (Ruiz & Pav.) Oken	Boraginaceae	X	
Corynaea crassa Hook. f.	Balanophoraceae	X	
Croton sp.	Euphorbiaceae	X	
Eucharis castelnaeana (Baill.) J.F. Macbr.	Amaryllidaceae	X	X
Myrcia acuminata DC.	Myrtaceae	X	X
Myrsine guianensis (Aubl.) Kuntze	Myrsinaceae	X	X
Oreopanax sp.	Araliaceae	X	
Scleria sp.	Cyperaceae	X	
Serjania clematidea Triana & Planch.	Sapindaceae	X	X
Smilax sp.	Smilacaceae	X	X
Zanthoxylum sp.	Rutaceae	X	X

Conservation status. A total of five *Z. huilensis* populations were located during our survey, and although plants were locally abundant, all occurred in forest fragments of less than 2 hectares that were surrounded by extensive cattle pastures. Several additional forest fragments with potentially suitable habitat were also explored in the vicinity of Altamira where Lehmann first collected this species in 1896, but no populations were found there.

The present extent of occurrence for this species adds up to 1100 km^2, and the whole area is severely degraded with only small forest remnants persisting near creeks or in ravines that are too steep to be useful for agriculture or cattle. The total area of occupancy for the species, calculated by adding the individual areas of the five *Zamia* populations visited, is 0.2 km^2. An estimated 250 adult plants were observed across all five populations.

The intense deforestation throughout the extent of occurrence of this species in southern Huila, combined with a paucity of botanical exploration in the region, may explain why this species remained poorly collected and little understood previous to this study.

The major threats to the species include deforestation for agriculture and cattle ranching as well as the illegal harvesting of plants for ornamental purposes. Based on the limited area of occupancy and the severe fragmentation of the forests within its extent of occurrence, we recommend an IUCN Red List Category of CR (Critically Endangered) for this species based on criteria A4cd + B2ab(i-v) (IUCN, 2001). Specific locality information has been purposefully withheld from this paper to minimize the risk of illegal harvesting of this critically endangered species.

Additional specimens examined. COLOMBIA. **Huila:** Altamira, 600-1200 m, 1896, *F.C. Lehmann* s.n. (K); Algeciras, 1100 m, 15 jan 1945, *E.L. Little Jr.* 9273 (COL, P, S, UC, US); 10 dec 1942, *F.R. Fosberg* 19304 (NY, P); 1000-1100 m, 12 jan 2012,

H.E. Esquivel et al. 3790 (ANDES, BOG, CAUP, CHOCO, FMB, HPUJ, HUC, JBGP, LLANOS, MEDEL, PSO, TULV, UDBC, UIS, UPTC, UTMC, VALLE); 1500-1750 m, 4 feb 2012, *H.E. Esquivel & Y.A. Mora* 3797 (COAH, TOLI); Hobo, 1500-1650 m, 23 jan 2012, *Y.A. Mora* 77 (COL, SURCO, TOLI). Garzón, 1000-1100, jan 2012, *J. Morales* 1. (SURCO). Pitalito, 1700 m, 8 oct 2012, *J.L. Peña et al.* 001 (HUAZ).

In Stevenson's (2001, 2004) treatments of Colombian Cycadales, the two specimens collected near Algeciras as well as specimens collected in Tolima were listed as belonging to *Z. poeppigiana* Mart & Eichler. Recent fieldwork in Tolima established that the Tolima collections belong to a large, arborescent species, now formally described as *Z. tolimensis* Calonje, H.E. Esquivel & Stevenson (Calonje et al., 2011). In this same publication, a detailed treatment was provided for *Z. poeppigiana*, endemic to Amazonian forests of Perú, as well as the morphologically similar species *Z. lindenii* Regel ex André from Pacific coastal forest remnants of Ecuador and northwestern Peru. Neither taxon occurs in Colombia and both are much larger plants that are not likely to be confused with *Zamia huilensis* and, therefore, will not be discussed further in this paper.

Zamia huilensis has coriaceous leaflets with toothed margins and abruptly acuminate tips and it is vegetatively most similar to *Z. muricata* Willd., which is native to Venezuela and northeastern Colombia. However, *Z. muricata* has subterranean stems, dark brown to black ovulate strobili with long peduncles (16-28 cm long), and grey pollen strobili with microsporophylls bearing 12-16 microsporangia segregated into two separate groups along margins. In contrast, *Z. huilensis* is arborescent, and has beige-yellow to beige ovulate strobili with short peduncles (2-5 cm long), beige-yellow pollen strobili with microsporophylls bearing 37-43 microsporangia aggregated into a single group.

Zamia huilensis shows similarities to *Z. tolimensis*, as it shares an arborescent habit; ovulate strobili with short peduncles and slightly protruding terminal facets; and microsporophylls with microsporangia aggregated into a single group. However, *Z. tolimensis* is a much larger plant than *Z. huilensis* in all respects, and it is easily differentiated by vegetative and reproductive characters as summarized in Table 2 and the following key.

Table 2. Distinguishing traits of *Zamia huilensis* and *Z. tolimensis.*

Trait	*Z. huilensis*	*Z. tolimensis*
Habitat and geographic distribution	Premontane moist forests of the Eastern Cordillera in Huila, 1000-1750 m.	Lower montane wet forests and montane rain forests of the Central Cordillera in Tolima, 1400-2000 m.
Leaflet size	16-29 x 3.8-4.6 cm	30-45 x 2.2-4 cm
Leaflet shape	Straight (not falcate)	Falcate
Leaflet dentation	Teeth present below distal half, 20 or more per leaflet	Margins entire or with few teeth (<16) limited to distal half
Stem length	To 1.1 m	To 4 m
Pollen strobilus size	To 14 x 3 cm	To 31 x 4.5 cm
Microsporangia per microsporophyll	37-43	41-63
Ovule attachment	Ovules not attached to flattened tomentose appendages protruding beyond bullae	Ovules attached to flattened tomentose appendages protruding beyond bullae
Sclerotesta size	2-2.3 cm long x 1.4-1.8 cm wide	2.8-3.6 cm long x 2.1-2.4 cm wide

Key to *Zamia tolimensis* and *Z. huilensis*

1 Median leaflets falcate 30-45 cm long, with entire margins or with few teeth (typically < 16) limited to the distal half of leaflet. *Z. tolimensis*

1' Median leaflets straight (not falcate), 16-29 cm long, with marginal teeth beginning below distal half, typically 20 or more per leaflet. *Z. huilensis*

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LITERATURE CITED

Calonje, M., H.E. Esquivel, D. Stevenson, C. Calonje & D. Pava. 2011. A new arborescent species of *Zamia* from the Central Cordillera of Tolima, Colombia (Cycadales, Zamiaceae), with comments on the *Z. poeppigiana* species complex. Brittonia 63: 442-451.

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones & A. Jarvis. 2005. Very high resolution interpolated climate surfaces for global land areas. International J. Climatology 25: 1965–1978.

Holdridge, L.R. 1967. Life zone ecology. Tropical Science Center. San José, Costa Rica.

IUCN. 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge.

Stevenson, D.W. 2001. Cycadales. Flora de Colombia, Monogr. 21. Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá, D.C.

Stevenson, D.W. 2004. Cycads of Colombia. Bot. Rev. 70: 194-234.

Stevenson, D.W., K. Norstog & P. Fawcett. 1998. Pollination biology of cycads. In S. Owens & P. Rudall (eds.), Reproductive Biology: In systematics, conservation, and economic botany. Pp. 277–294. Royal Botanic Gardens, Kew.

Tang, W. 1987. Insect pollination in the cycad *Zamia pumila* (Zamiaceae). American Journal of Botany 74: 90–99.

Vovides, A.P. 1991. Insect symbionts of some Mexican cycads in their natural habitat. Biotropica 23(1): 102–104.

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